# FILTER ELEMENTS HAVING INJECTION MOLDED THERMOPLASTIC SEALS AND METHODS OF MAKING SAME

## Related Patent Applications:

This application is a continuation-in-part of U.S. Patent Application No. 10/404,109 filed April 2, 2003, incorporated herein in its entirety.

## Field of the Invention:

The present invention is directed to filter elements having injection molded thermoplastic seals and methods of making such filters. More particularly, the present invention is directed to filter elements having generally planar filter media packs which are usually polygonal, wherein thermoplastic elastomer seals are molded thereon.

## Background of the Invention:

Filter elements include seals for isolating the clean and dirty sides of the filter element from one another so that a fluid such as a gas or liquid does not bypass filter media comprising the filter element. The current practice is to use a casting process to fix foamed urethane seals to the filter media. Generally, this is done by injecting a two part liquid such as a polyol and isocyanate mixture into a mold having filter packs encased therein. Under heat the liquid mixture foams to create urethane seals on the filter media packs. The foamed urethane seals are designed to withstand sustained temperatures of about 200°F and will tolerate up to about 275°F for brief periods. Sustained temperatures at the 275°F level can cause the seals to become thermoplastic and degrade by

reshaping themselves. This is because the cells of the foamed urethane tend to collapse resulting in the seal becoming a less compressible solid and thus loosing its flexibility. This collapse can reduce the volume of the urethane by 200-300% and thus reduce the effectiveness of initially foamed urethane as a seal. Moreover, urethane seals tend to bond with filter element housings made from NYLON® when subjected to higher temperatures, making it difficult to remove filter elements from NYLON® housings during periodic maintenance.

**Summary of the Invention:**

In view of the aforementioned considerations, the present invention is directed to a filter element comprising a pleated filter media having filter face portions and side portions joined thereto by corner portions, and comprising a seal of substantially solid thermoplastic material disposed at least on one of the corner portions; the seal having a portion which flexes under a bending moment protruding from the adjacent filter face portion, and the seal having been formed on the corner portion by injection molding.

In a further aspect of the invention, the thermoplastic plastic material is a thermoplastic vulcanizate (TPV) such as ethylene-propyleneterpolymer (EPDM) embedded in polypropylene.

In another aspect of the invention, the filter element is a panel air filter element comprising a pleated filter media having a dirty-side face portion and a clean-side face portion joined to one another by end surfaces and side surfaces at corner portions. A substantial solid thermoplastic seal is disposed at one of the corner portions and extends obliquely from the plane of the face portion on

which the corner portion is formed, as well as protruding laterally with respect to the end surfaces and side faces. The thermoplastic seal is formed at the corner by injection molding the thermoplastic material on and between the pleats of the pleated filter media at corner portions of the filter media.

In accordance with a method of making filter elements according to the present invention, the method is directed to inserting a filter media into an injection molding machine, and thereafter injecting a thermoplastic seal around the periphery of a face of the pleated filter media while the filter media is in the injection molding machine to form the filter element. The filter element is then ejected from the injection molding machine. Additional individual filter media are then sequentially inserted to the injection molding machine after previously formed filter elements have been ejected so as to provide a continuous production of individual filter elements.

**Brief Description of the Drawings:**

Various other features and attendant advantages of the present invention will be more fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and wherein:

Fig. 1 is a side perspective view of a filter element configured in accordance with the principles of the present invention;

Fig. 2 is an end perspective view of the filter element of Fig. 1;

Fig 3 is a clean-side face view of the filter element of Figs. 1 and 2;

Fig. 4 is a dirty-side face view of the filter element of Figs. 1-3;

Fig. 5A is an end elevation of a portion of the filter element showing a first embodiment of a seal configured in accordance with the present invention;

Fig. 5B is an end elevation of a second embodiment of a seal configured in accordance with the present invention;

Fig. 5C is an end elevation of a third embodiment of a seal configured in accordance with the present invention;

Fig. 5D is an end elevation of a fourth embodiment of the invention showing a seal molded onto a frame;

Fig. 6 is a view of the portion of the filter element of Fig. 5 showing that portion mounted in a housing with the lid of the housing open;

Fig. 7 is a view similar to Fig. 6 but showing the lid of the housing closed;

Fig. 8 is a schematic side view showing a method of making filter elements in accordance with the principles of the present invention, and

Fig. 9 is a schematic side view showing the method of Fig. 8 including molding a frame around a filter media pack prior to molding a seal thereon.

**Detailed Description of the Drawings:**

Referring now to Figs. 1-4, there is shown a filter element 10 configured in accordance with the principles of the present invention wherein the filter element has a pleated paper filter media 12 with a clean side face 14 (Fig. 3) and a dirty side face 16 (Fig. 4). The filter media 12 also includes first and second end surfaces 20 and 22 (Fig. 1) and first and second side surfaces 24 and 26 (Fig. 2). The end surfaces 20 and 22 are flat portions of a continuous web 28 of filter

media comprising the filter media 12. The side surfaces 24 and 26 extend normal to gaps 30 between adjacent pleats 32 of the filter media.

The end surfaces 20 and 22 and the side surfaces 24 and 26 of the filter media 12 join the clean side face 14 at corner portions 32, 33, 34 and 35, while the dirty side face 16 joins the end surfaces and sides at corner portions 37, 38, 39 and 40.

It is necessary to isolate the clean side face 14 of the filter element 10 from the dirty side face 16 in order to cause all of the fluid passing through the filter element to be filtered by the filter media 12. This is accomplished by a peripheral seal 50 which is disposed through and on the clean side corner portions 32-35.

In the illustrated first embodiment, seal 50 has four sections 52, 53, 54 and 55 which have the same cross sectional configuration. Each of the four sections 52-55 has flexible resilient flanges of solid rather than foamed material that extend both laterally and outwardly with respect to the plane defined by the clean side face 14 of the filter media 12.

As is seen in Fig. 5A, the seal 50 has a first flexible flange 56 is separated by from a second flexible flange 58 by a gap 59. The first flexible flange 56 extends obliquely and laterally inwardly with respect to a plane 60 defined by the clean side face 14, while the second flexible flange 58 extends obliquely and laterally outwardly with respect to the plane 60. When the flexible flange 56 and 58 are pressed against a surface of a housing the flanges bend away from one another widening the gap 59 with the flange 58 bending.

The second flexible flange 58 is separated by from a third flexible flange 61 by a gap 62 while the first flexible flange 56 is separated from a fourth flange 63 by a triangular gap 64. Injection molded material 65 from the fourth flange 63 extends across the clean face 14 of the filter media 14 and into the gaps 32 between the pleats 30. The third flange 61 is separated from a rim 67 of the seal 50 by a notch 68 with a portion 69 of the rim extending into the gaps 32 between the pleats 30.

The fourth flange 63, injection molded material 65, rim 67 and portion 69 of the rim form a base portion B of the seal 50 which is integral with filter media 12 after injection mold. The flexible resilient flanges 56 and 58 provide contact portions C of the seal which have anchor portions A which are unitary with the base portion B and free ends F which are engagable by the lid of the housing. As the lid closes, the flexible resilient flanges 56 and 58 bend with compression against the lid being provided by the bending moment in the flanges.

Referring now to Fig. 6 where the portion of the filter element of Fig. 5 is shown mounted in a housing 75, it is seen that a ledge 76 of the housing projects into the notch 68 of the seal 58 so that the third flange 61 of the filter element 50 rests on the ledge 76 of the housing 75 with the filter media 12 extending into the opening 77 through the housing.

Referring now to Fig. 7, where the lid 79 of the housing closes, the first and second flexible flanges 56 and 58 bend toward the fourth flange 63 and the third flange 61, respectively, widening the triangular gap 59 and narrowing the triangular gaps 62 and 64. The pressure of the lid 79 against the first and second flanges 56 and 58 urges the third flange 61 against the ledge 76 of the

housing, further sealing the clean side 14 of the filter element 10 from the dirty side 16.

The seal 50 is solid without the cells of prior art seals, so that the first and second flanges 56 and 58 provide contact portions of the seal which bend and assert compression against the lid 79 due to bending moments because force from the lid is applied to the free ends F of the first and second flanges. While two flanges are shown, a seal could also be accomplished with a single flange or with another configuration of contact portions the seal which rely on bending rather than compression of the seal material itself. Examples of other configurations for contact portions are circular, oval or polygonal contact portions.

Fig. 5B shows a U-shaped contact portion 80 having a first leg 81 extending from and unitary with a base portion 82 of a seal 50' and a second leg 83 connected by a bight 84 to the first leg. Upon engaging the outer surface 85 of contact portion 80 with the lid 79 of the housing 75 (see Fig. 7), the bight 84 bends because the second leg 83 deflects toward the first leg 81 into the gap 86 therebetween.

Fig. 5C shows a third embodiment of a seal, seal 50", configured in accordance with the present invention, wherein the seal 50" is hollow, preferably without a vent opening therein. The hollow seal 50" has continuous void 88, which is preferably round or oval in cross section, and which deforms in a radial direction when compressed by a housing cover.

In accordance with the present invention, the seal 50 is preferably comprised of a thermoplastic elastic material (TPE) such as thermoplastic

particles embedded in ethylene-polylene terpolymer rubber (EPDM). While this type of material is preferred, other elastic and resilient thermoplastic materials which are capable of being injection molded on and into the corners, 32, 33, 34 and 35 at the periphery of the filter media pack 12 may be used.

Referring now to Fig. 8, there is shown apparatus for making the filter element 10 shown in Figs. 1-4 according to a method of the present invention, wherein a production run for numerous filter elements 10 is illustrated. Apparatus for practicing the method of the invention includes a conveyer 90 on which is mounted the bottom section 91 of a two-section mold 92. The pleated filter media 12 is inserted into the bottom mold section 91 prior to, or in conjunction with, mounting a seal mold section 95 on the bottom mold section 91. In another arrangement, the seal mold section 95 may be integral with injection molding machine 100 (as shown) and the bottom mold section 91 may simply be advanced into alignment with the seal mold section 95 with the mold 92 being shut at an injection molding station 102.

In the injection molding machine 100, a barrel 104 is heated by heaters 105 while solid thermoplastic pellets are fed into the barrel 104 from a hopper 106. The thermosetting material 107 of the pellets is carried by a screw 110 within the barrel 104 down to a nozzle portion 111 of the barrel for injection into the seal mold section 95, which shapes the seal 50 as a ram 102 injects the molten material 107 into the seal mold section 95. It takes approximately thirty seconds for the seal 50 to cool and solidify. The mold 92 is then opened by separating the seal mold section 95 from the bottom mold section 91 and the

finished filter element 10, comprised of the filter media 12 and seal 50, is ejected from the bottom mold section 91.

A subsequent bottom mold 91 carrying another filter media pack 12 is then aligned and closed by the second section 95. Approximately thirty seconds later, a second complete filter element 10 comprised of a filter media 12 and seal 50 is ejected.

Referring now to Fig. 5D there is disclosed a fourth embodiment of the invention wherein a rigid frame 120 is molded onto the filter media pack 12 prior to molding the seal 50' to create the filter element 10'. The rigid frame 120 has portions which flowed between the pleats of the pleated filter media 12 and adhered to the panels thereof adjacent the top corner 124 of the filter media. The rigid frame 120 is relatively hard and is made of a thermoplastic material such as polypropylene, polyurethane or polyethylene. When the seal 50' is ejected over the frame 120, the seal adheres to the frame. This results in a relatively stiff filter element 10'.

Referring now to Fig. 9 there is shown a method of making the filter element 10' of Fig. 5D, wherein an injection molding machine 130, configured like the previously described injection molding machine 100, injects molten material 132, such as polypropylene, polyurethane or polyethylene onto the filter pack 12 to form the frame 120. The mold section 95' distributes the molten material 132 along and around the upper edge 124 of the filter pack 12. After solidifying, the frame 120, receives the sealing material 107 thereon which is injected by the injection molding machine 100. The resulting filter element 10', rigidified by the frame 120, is then ejected from the bottom mold section 91.

The filter element is configured to accommodate the shape of the filter element housing, which, housing may be configured to save space and to nest within a convenient location with respect to an engine.

While a rectangular panel filter element is disclosed as produced and configured in accordance with the principles of the present invention, the filter element may have other than a rectangular or square shape. For example, the filter element many be circular, triangular, or be polygonal with more than four sides, such as generally rectangular filter element with having an additional short side or corner side for filter element orientation.

The filter element may also be annular with the seals being disposed at one or both end faces by utilizing thermal setting materials which have been injection molded onto the annular filter media. While pleated cellulose or cellulose blend filter media is disclosed in the embodiment of this application, other types of filter media which have woven or non-woven polymer strand filter media (such as polyester or polypropylene strands) or foam-type filter media may utilize injection molded thermoplastic seals as set forth in this invention.

From the foregoing description, one skilled in the art can easily ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the invention to adapt it to various usages and conditions.